823A
JJW:BT
1/11/66

This invention relates to an improved process for the recovery of bitumen from bituminous sand and more particularly to a process which results in increased recovery of bitumen from such sand.

Large deposits of bituminous sand are found in various localities throughout the world. The term "bituminous sand" is used herein to include those materials commonly referred to as oil sand, tar sand and the like. One of the most extensive deposits of bituminous sand occurs, for instance, in the Athabasca district of the Province of Alberta, Canada.

Typically the composition of these sands contain, by weight: from about 6% to about 20% of oil; from about 1% to about 10% of water; and from about 70% to about 90% of inorganic solids. The specific gravity of the bitumen varies from about 1.0 to about 1.05. (The specific gravity of the bitumen as well as all other values of specific gravity given herein are taken at 60°F.) The major portion, by weight of the inorganic solids is fine grain quartz sand having a particle size greater than about 45 microns and less than 2000 microns. The remaining inorganic solid matter has a particle size of less than 45 microns and is referred to as fines. The fines contain clay and silt including some very small particles of sand. The fines content typically varies from about 10% to about 30% by weight of the solid inorganic content of bituminous sand. The true specific gravity of the sand is about 2.65 whereas that of the fines is about 2.7. However, the composition of bituminous sand can vary from the above mentioned ranges and this is not too uncommon. Also, in mining the bituminous sand, clay which is found in layers of varying

thickness in such sand areas, may be admixed with the bitumen, thus increasing the inorganic solids content and particularly the fines content of the material to be processed.

Various methods have been proposed for separating bitumen from bituminous sand. The two best known methods are often referred to as the "hot water method" and the "cold water method." In the former the bituminous sand is jetted with steam or hot water and mulled with a small proportion of water at about 175°F., and the pulp is then dropped into a turbulent stream of circulating water and carried through a separation cell maintained at an elevated temperature of about 180°F. In the separation cell entrained air causes the oil to rise to the top in the form of a froth rich in bitumen which is then drawn off.

The so called "cold water method" does not involve heating the bituminous sand other than whatever heating might be required to conduct the operation at room temperature. The process involves mixing the bituminous sand with water, soda ash and an organic solvent such as kerosene. The mixture is then permitted to settle at room temperature. A mixture of water and bitumen dissolved in the organic solvent rises to the top of the settling zone and is recovered.

Both the hot water and cold water processes mentioned above, as well as many variations on these processes and other processes suggested for recovery of bitumen from bituminous sand, involve a settling or separation step in which a fluid slurry of bituminous sand is introduced into a body of water so that bitumen rises to the top of a body of water, usually in the form of a froth, while sand settles to the bottom. In all such processes the separation of oil from solids is not

complete and some bitumen and solids, mostly fines, remain in the water. This is especially true where water or gas stripping is employed to assure complete removal of bitumen from solids. As the proportion of fines in the water builds up, the froth or overflow product will be found to contain increasing percentages of inorganic solids. These fines are extremely difficult to remove from the froth and it is desirable to prevent any increase in the amount of fines carried over in the froth product due to build up of fines in the water. While this adverse effect upon the solids content of the froth might be avoided by merely discarding water containing fines and bitumen on a continuous basis, such a course of action would result in loss of the very significant amounts of bitumen associated with the fines in the water and in most cases would be impractical because of the pollution of the water by the bitumen. To solve this problem it has been suggested that water containing fines and bitumen might be passed through a separate settling zone with clarified water being recycled or discarded and the sludge of fines and bitumen being discarded as waste sludge. Such a solution might be practical for very small scale operations but on a commercial scale it is impractical because of the difficulty of disposing of the quantities of oily sludge which would result from this treatment. The present invention is intended to provide a solution to the problem described above.

It is an object of the present invention to provide an improved process for the recovery of bitumen from bituminous sand.

Another object of the invention is to provide a process for the recovery of bitumen from bituminous sand in which bitumen recovery is improved and waste disposal problems are minimized.

3823A

These objectives may be accomplished in accordance with the present invention by floating a froth containing bitumen on a body of water contained in a separation zone as described generally above while allowing sand to settle to the bottom of the separation zone and then removing a stream of water containing fines and bitumen from an intermediate portion of the separation zone and subjecting the same to an air flotation treatment to remove additional bitumen in the form of froth before allowing fines to settle out of the mixture. Once the remaining bitumen has been removed from the fines by the flotation treatment the fines are allowed to settle and may be discarded as waste sludge. In this manner additional bitumen is recovered and the waste sludge is substantially free of contaminating bitumen.

These and other aspects of the invention will be more fully understood by reference to the accompanying drawing, which is a diagramatic illustration in which equipment is shown in elevation of a suitable arrangement of apparatus for carrying out a preferred embodiment of the present invention.

Referring to the drawing, bituminous sand entering through a conduit 12 may be mixed with water and steam in a mixer 13. Water may enter as through a conduit 14 and steam through a conduit 16. In the mixer 13 the bituminous sand is thoroughly moistened and mixed with the water to form a thick slurry. The mixer 13 may take any suitable form such as a conventional rotating cylindrical tumbler having perforations for the slurry to drop out through and provision for rejecting, as through a conduit 17, oversized rocks and lumps of sand which cannot be broken down.

3823A

The slurry formed in the mixer 13 is removed through a conduit 18 and passed to a flood cell 19 where it is further mixed with additional quantities of water introduced through a conduit 20 and passed through a conduit 21 to a settling tank 22 in which it is placed in a body of hot water. In the settling tank 22 air entrained in the slurry during the mixing and flooding steps causes bitumen to rise to the upper surface of the water in the form of a froth while sand is allowed to settle to the bottom of the settling tank. Air may be introduced into a lower stripping portion 25 of the settling tank as through a conduit 23 in order to strip additional bitumen from the sand and water may be introduced through a conduit 24 for the same purpose. Sand is withdrawn from the settling tank 22 through a conduit 26 while a froth containing bitumen may be withdrawn from the settling tank through a conduit 27. Water containing fines and bitumen not separated in the settling tank 22 may be withdrawn from an intermediate portion of the settling tank as through a conduit 28 and passed to a flotation unit 29.

Air, preferably at least partially dissolved in liquid, introduced through a conduit 31 is utilized in the flotation unit to separate additional bitumen from fines with the bitumen floating to the top as a froth and the fines settling to the bottom as a sludge which can be removed in a water slurry through a conduit 32. Froth containing bitumen may be removed from the upper portion of the unit through a conduit 33. In order to insure that fines do not settle from the water before being contacted with the air in the flotation unit 29, a conventional mixer or impeller 34 may be used to insure that the fines, water and bitumen are thoroughly mixed prior to the air flotation treatment.

While the invention is described herein primarily in conjunction with a hot water process of the type described above, it should be understood that it is useful in connection with any process for recovery of bitumen from bituminous sand in which the bitumen is floated to the top of a body of water and solids are allowed to settle to the bottom thereof. Any such body of water is subject to build-up of fines and associated bitumen as described above. It is within the scope of the invention to withdraw water containing fines and bitumen from any intermediate portion of any such body of water and subject the same to air flotation in order to recover additional bitumen and insure that the fines when ultimately discarded contain the least possible amount of bitumen.

The slurry introduced into the settling tank 22 as described above may be of widely varying composition but when operating under normal conditions of the hot water process preferably includes between about 40 and about 55 weight per cent (wt %) water and may contain between about 5 and about 10 weight per cent organic solvent with the remainder of the weight being bitumen and solids. Slurry is mixed and agitated in the mixer and flood cell at temperatures preferably between about 160 and between 200°F and the settling tank 22 is preferably maintained within this same temperature range. The mixing and agitation of the slurry preferably entrains sufficient air in the slurry so that the slurry as introduced into the settling tank 22 contains between about 1 and about 20 volume per cent (vol %) air. Suitable aeration gas such as air, methane nitrogen or carbon dioxide is preferably introduced through the conduit 23 at rates between about 150 and about 360 standard cubic feet per hour per square foot of cross sectional area (SCF/hr/ft^2)

3823A of the lower stripping portion 25 of the settling tank 22 and water may be introduced through the conduit 24 at a rate between 500 and about 2500 lbs per hour per square foot ($lb/hr/ft^2$). Solids passing through the stripping portion 25 of the settling tank preferably total between about 2500 and about 7500 $lb/hr/ft^2$.

Water withdrawn through the conduit 28 and passed to the flotation unit 29 frequently contains between 0.05 and about 2.0 weight per cent bitumen and between about 2 and about 5 weight per cent fines with a weight ratio of bitumen to fines between about 0.01 and about 1.0. In the flotation unit 29 the water is treated with air, preferably in amounts between about 0.002 and about 0.004 standard cubic feet per hour per pound of water introduced through the conduit 28 in order to float additional bitumen to the top of the body of water located in the flotation unit 29. This air is preferably introduced into the flotation unit at least partially dissolved in water and it has been found that the dissolved air is superior to diffused or entrained air for the treatment of contaminated water from the settling tank. In accordance with conventional dissolved air flotation techniques, the air is dissolved in water under superatmospheric pressure such as between about 40 and about 60 p. s. i. g. and when water is introduced into the flotation unit, the reduction of pressure allows the air to come out of solution in the form of extremely small air bubbles which are highly effective in removing bitumen from the fines. As mentioned above, it is essential for the proper operation of the process that the air flotation treatment of the contaminated water from the settling tank take place before such water is subjected to settling for removal of fines. In this way additional bitumen is recovered and the fines are

3823A substantially free of bitumen when they are settled and withdrawn from the flotation unit. By this process, the weight ratio of bitumen to fines in sludge withdrawn following the flotation treatment is usually at least 50% less than the weight ratio of bitumen to fines in the contaminated water passed to the flotation unit for treatment.

The following example illustrates the application of the present invention in recovery of bitumen from bituminous sand in a typical hot water type process which has been modified to include the addition of air and water to the settling tank as described above.

EXAMPLE I

Bituminous sand containing 9.5 weight per cent bitumen, 84.3 weight per cent solids (of which 10.8 weight per cent are fines) and 6.2 weight per cent water is introduced into the mixer 13 through the conduit 12 at the rate of 1000 lbs. per hour. In the mixer 13 the bituminous sand is moistened, heated and thoroughly mixed with hot water introduced through the conduit 14 at the rate of 780 lbs. per hour and steam introduced through the conduit 17 at a rate of 96 lbs. per hour. An aqueous slurry of bituminous sand containing 45 weight per cent water is passed through the conduit 18 to the flood cell 19 where additional water is added through the conduit 20 to form a slurry containing 55 weight per cent water. This slurry, which contains 5 volume per cent air, is passed through the conduit 21 into a body of water maintained at a temperature of 180°F in the settling tank 22. Air is introduced into the lower stripping portion 25 of the settling tank through the conduit 23 at the rate of 360 SCF/hr/ft^2 and water is introduced through the conduit 24 at the rate of 2000 lb/hr/ft^2. 275 pounds per hour of water and 796 pounds

3823A per hour of sand are removed from the settling tank through the conduit 26. Froth containing 8.9 weight per cent solids, 48.7 weight per cent bitumen and 42.4 weight per cent water is removed through the conduit 27 at a total rate of 131 lbs. per hour. Water containing 1.5 weight per cent bitumen and 8.0 weight per cent fines is removed through the conduit 28 at a rate of 1066 lb/hr and passed through the flotation unit 29. In the flotation unit 29 the contaminated water is thoroughly mixed by the impeller 34 to insure that fines do not settle out prematurely and is then subjected to settling and air flotation with air being introduced at the rate of 0.002 standard cubic feet per hour per pound of water introduced through the conduit 28. Half of this air is dissolved in recycled water supplied at the rate of 1 pound per hour per pound of water introduced through the conduit 28. 942 pounds of water and 82 pounds per hour of fines are withdrawn through the conduit 32. Bitumen content of the fines withdrawn through the conduit 32 is limited to 8 weight per cent. The froth removed through the conduit 33 consists of 55.5 weight per cent water, 37.4 weight per cent bitumen and 7.1 weight per cent solids and is withdrawn at a total rate of 41 lbs. per hour.

EXAMPLE II

The following experimental runs demonstrate the necessity for applying air flotation treatment to water contaminated with fines and bitumen prior to settling and removing fines from such water. In these runs, water obtained from a settling tank such as 22 and contaminated with fines and bitumen was treated by two different techniques. The first technique (A) involved settling the water without prior treatment and recovering a sludge from the bottom of the settling tank.

3823A The second technique (B) involved treating the water by dissolved air flotation prior to any settling and then, after the flotation treatment, allowing the water to settle and recovering sludge therefrom. Results are shown in table I below.

Table I

Water from Stream No.	Bitumen Content of Sludge (expressed as a percentage of weight of solids in sludge).	
	Treatment (A) (settling only)	Treatment (B) (flotation followed by settling)
1	10%	2.5%
2	19%	8 %
3	118%	11 %

The above data shows very clearly that the air flotation treatment prior to selling results in very substantial reductions in the bitumen content of the sludge ultimately recovered for disposal.

While the invention has been described above with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended to cover all such changes and modifications in the appended claims.

3823A The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In the process for the recovery of bitumen from bituminous sands in which a fluid slurry of bituminous sand is introduced into a separation zone containing a body of water and in which bitumen is floated to the top of such body of water and recovered therefrom while sand is allowed to settle to the bottom of such body of water, the improvement which comprises withdrawing water containing bitumen and fines from an intermediate portion of such body of water and passing the same to a flotation zone wherein it is contacted with upwardly flowing aeration gas to recover additional bitumen therefrom.

2. The process of claim 1 in which the aeration gas is introduced into the flotation unit dissolved in a liquid.

3. The process of claim 1 in which the mixture of water, fines and bitumen withdrawn from the separation zone is agitated immediately prior to contact with the aeration gas.

4. The process for separating bitumen from bituminous sand which comprises:

a) forming an aqueous slurry of said bituminous sand;

b) introducing said slurry into a settling zone containing a body of water and allowing bitumen to float to the top of said body of water and solids to settle to the bottom thereof; and

c) withdrawing water containing bitumen and fines from an intermediate portion of said settling zone and passing same to a flotation zone wherein it is contacted with aeration gas to thereby recover additional bitumen from said fines.

3823A 5. The process for separating bitumen from a bituminous sand slurry which comprises:

a) introducing an aqueous slurry of bituminous sand containing entrained air below the surface of a body of water whereby bitumen rises to the top of said body of water in the form of a froth while allowing solids in said slurry to pass downwardly through said body of water;

b) removing water containing fines and bitumen from an intermediate point in said body of water;

c) passing said water containing fines and bitumen, without removal of fines to a second body of water;

d) introducing water containing aeration gas under pressure into said second body of water whereby gas bubbles are formed in said second body of water and pass upwardly therethrough to thereby float additional bitumen to the surface of said second body of water; and

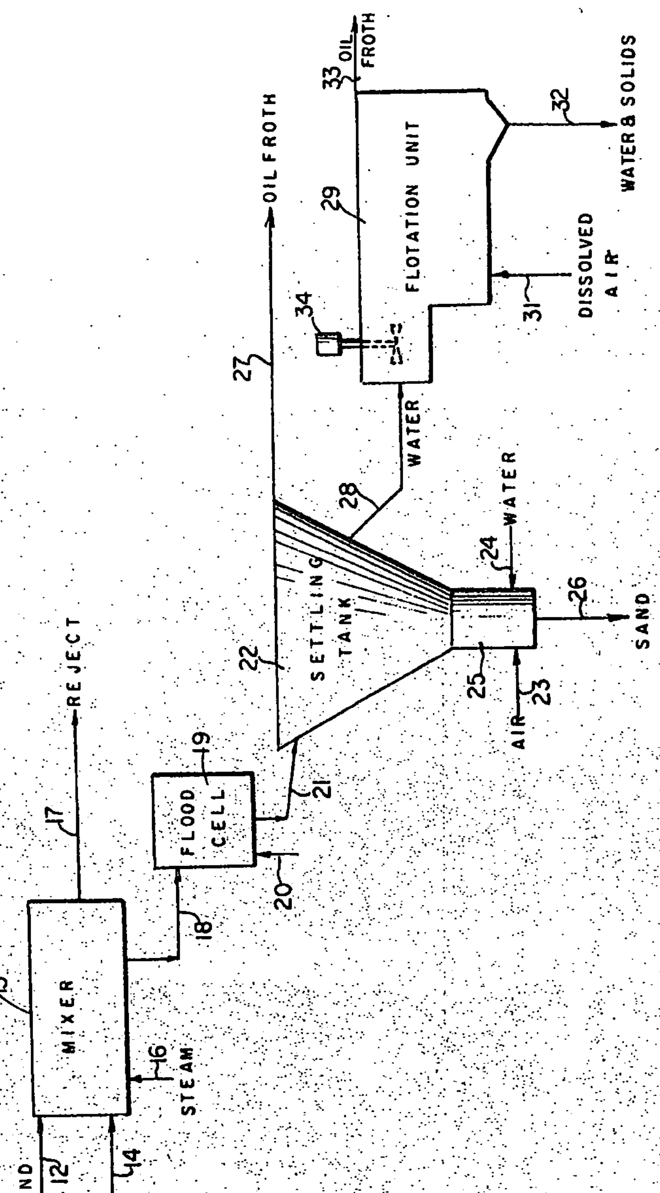
e) recovering froth containing bitumen from the surface of each of said bodies of water and removing solids from the lower portions of each of said bodies of water.

6. The process according to claim 5 in which water removed from the first body of water contains between about 2 and about 5 weight per cent fines and between 0.05 and about 2 weight per cent bitumen and in which the weight ratio of bitumen to fines in such water is between about 0.1 and about 1 while the weight ratio of bitumen to fines in material removed from the lower portion of the second body of water is reduced by at least about 50%.

7. The process of claim 5 in which the water containing fines and bitumen removed from the first body of water is thoroughly agitated

3823A immediately prior to being introduced into the second body of water to prevent premature settling of fines therefrom.

8. The process of claim 5 in which aeration gas introduced into the second body of water is at least partially dissolved in water and is utilized in rates between about 0.002 and about 0.004 standard cubic feet per hour per pound of water introduced into said second body of water.



INVENTORS.

J. D. Frame

M. P. Du Plessis

PATENT AGENT

Smart + Biggar